Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE EFFICIENCY OF HOUSEHOLD FILTERS IN CHICAGO

By Arthur Lederer[1] and Frank Bachmann[2]

The efficiency of household filters has on numerous occasions been studied, mainly, however, with reference to one or the other type of filters. We are not aware of any investigation which has been undertaken in a large city with a view of obtaining information on the quality of household filtered water in general. It was not our intention to study individual types of filters, the pro and con of their construction, or the uniformity of results obtainable at various times. The question before us was: What is the quality of the water obtained from household filters in Chicago at the present time? Such an investigation should necessarily be sufficiently extended to supply data for a fair average, including both efficient and worthless filters, filters cared for intelligently and others totally neglected, some widely advertised and others comparatively unknown. Unless an investigation of this kind is broad enough to cover the examination of a sufficiently large number of filters, one type of filter might possibly prove to be better or worse than it really deserves. In examining about 80 filters, for instance, we have found only one filter of a certain type. This, of course, should not be taken to mean that this particular filter has not been a good seller. Over 1000 filters should be tested in a city of the size of Chicago to learn approximately the ratio of use of various types in households.

There is still another angle to be considered. The more filters of one particular make are examined, the more accurately is it possible to draw conclusions; but even where but one filter of one particular type is examined, certain definite conclusions of negative value can be arrived at. If this single examination of a certain type of filter shows a very low bacterial count in the effluent, or even sterility, it does not mean this particular type should be recommended, unqualifiedly, without making more frequent tests and a more thorough investigation. On the other hand, if this single test shows a poor effluent from a bacterial standpoint, there is good cause for condemning the filter, since it indicates that at times the filter effluent might not even be as good as the raw water. Of course, it is self-evident that a filter may give poor results not because of faulty construction but because of lack of proper care. This, however, does not necessarily relieve the manufacturer of such product from criticism. Any manufacturer of household filters who has not yet learned this lesson must come to recognize that it is impossible to produce an entirely fool-proof filter and that the most ingenious and scientifically correct types will shipwreck on the human element which enters into the supervision and care required to retain continuous efficiency. Directions are worthless, or practically so, unless they are followed in more than a perfunctory manner.

---

[1] Chemist and Bacteriologist, the Sanitary District of Chicago.

[2] Assistant Chemist, the Sanitary District of Chicago.

What should be the function of an ideal household filter? The answer is simple. It should eliminate the turbidity and practically all of the bacteria at all times, without altering the palatability of the supply. It may seem rather severe to require a filter to furnish absolutely sterile water, hence from the standpoint of the sanitarian, the complete removal of gas forming bacteria when tested in 10 cc. of the water should prove satisfactory. Yet our investigation has shown that a certain type of filter will give an average of nearly 100 per cent bacterial removal. There is no reason then why we should not strive to attain a standard which is within our reach.

Various material is employed in the manufacture of these household filters, such as unglazed porcelain or kaolin, diatomaceous earth, natural stone, artificial stone, coal, asbestos, filter paper, etc. The types heretofore valued most highly by the scientific world have been the Pasteur-Chamberland type, in which the water is passed through unglazed porcelain bougies, and the Berkefeld type, which contains bougies of diatomaceous earth. Both of these filters are known to furnish sterile effluents under expert care. Such care, however, cannot be had in the ordinary house. The best filters prove bacteria proof for only a limited time under such conditions. The very fact that the turbidity is removed by most of those household filters, good as well as poor types included, conduces to an unjustified feeling of security. Micro-organisms are much smaller than most suspended matter, even the finely divided clay which constitutes the turbidity of our lake water. It is not surprising that bacteria pass through the minute pores of filters, even of the Pasteur and Berkefeld types. When first used, the effluent may be sterile, for the reason that these pores are tortuous. Certain bacteria multiply rapidly within the filter material and are finally forced through into the effluent by the water pressure. Still if the bougie or candle, as it is popularly called, is daily boiled or even cleaned two or three times a week, a reasonably safe supply seems assured with filters of that type, unless extreme conditions prevail.

Numerous experiments by others with artificially infected water have shown that B. coli communis, B. typhosus, and B. cholerae fail to pass through the candle, while the ordinary harmless water bacteria do. One observer has succeeded in growing B. typhosus through the walls of a Berkefeld candle. The shortest time for the typhoid bacili to grow through the walls of the candles was found to be four days, and it would therefore seem sufficient to clean and boil the candles twice a week. Of course, the fact that typhoid bacili have been grown through the walls of the candle is more of scientific rather than practical interest, for unusual conditions were established. It makes an enormous difference whether a pure typhoid culture passes through a filter or a polluted water containing a comparatively small number of these disease producing bacteria or a water which is comparatively free from any pollution. It is probable that even when a Berkefeld or Pasteur filter is not cleaned every three to four days, the typhoid bacteria, if present, would be completely eliminated. There is undoubtedly a biologic activity in these filters of which we have little concrete knowledge and which exerts a selective destructive action upon the intestinal group of pathogenic bacteria. It is understood, of course, that these observations apply not only to the Pasteur and Berkefeld filters, but also to the varied types which employ unglazed porcelain or diatomaceous earth for a filter material.

It is remarkable that among the 84 filters examined by us not one Berkefeld filter was found. The objection to the stone filters particularly to the natural stone filters, is that the pores are so large that they permit the accumulation of sediment and the propagation of bacteria, so that the effluent at times actually appears worse than the raw water entering the filter. The closer and finer the pores of a filter, the better the bacterial result. Increasing the rate of filtration implies uncertain results with domestic filters. Any attempt to force filtration by increasing the pressure or by substituting a more porous filtering material must of necessity be followed by poorer results.

Very often water may be contaminated in the storage reservoir after it has passed through the filter. Undoubtedly this has occurred in a number of cases with the effluents from the Pasteur-Chamberland filters (table I) and others. A construction which eliminates the chance of contamination of the filtered water, like the Red Cross type, is undoubtedly more desirable. As our purpose was to learn the quality of the water delivered to the consumer, the storage reservoir was considered a part of the filter, even if not furnished by the filter manufacturer. It may seem unjust to blame the contamination on the filter manufacturer when the filter alone delivers a safe supply, but the manufacturer must be prepared to shoulder the blame, as long as his filter and appurtenances does not completely eliminate the human element up to the time of actual consumption. In the majority of the filters, a separate storage reservoir is employed, usually a crock, glass bottles, or similar receptacles. The shorter the period of storage in the storage reservoir the less the chance for multiplication of undesirable species of bacteria which may have entered the reservoir through the filter or otherwise.

Our investigation of household filters in Chicago was carried on during January and February, 1914, and naturally was attended with much difficulty. Reliable, intelligent information is often very hard to obtain. The average housekeeper looks upon an investigation of her filter with suspicion, believing it to be a novel scheme to sell her a filter of another type. Often, the investigator is referred to the maid for information on the care of the filter, and in such cases the value of information obtained will be in direct proportion to the intelligence and interest of the informant. Nevertheless, we have endeavored to compile all the data possible on the care which each individual filter examined by us received. The examination of the water entering and leaving the filter was directed towards noting the bacterial and physical improvement. The physical improvement in a water supply like that of Chicago can best be judged by the elimination of the turbidity. The number of bacteria growing on gelatin at 20°C. in three days roughly serves as an index of the harmless types of water bacteria. The number of bacteria growing on litmus lactose agar at 37°C. in two days roughly serves as an index of the intestinal types, although not all of these types actually originate in the intestinal canal. An excessive number of these bacteria particularly when acid forming colonies are found on the culture plate, may indicate the possibility of sewage contamination. The numerical relation of the bacteria forming at 20°C. and 37°C. should be taken into account. The number of bacteria developing at 20°C. on gelatin may be extremely high, yet if no bacteria or very few develop on agar at 37°C., such high counts have little sanitary significance for they may be due to the rapid multiplication of certain harmless types. The presumptive fermentation test for colon bacili made by incubating various quantities of the water with lactose broth and incubating the mixture in fermentation tubes at 37°C. for two days is of great significance. If fermentation does not take place on inoculation with 10 cc. of the water, the water may be considered to be of good quality. We have not endeavored to test larger quantities of the filtered water for the presence of gas forming bacteria.

Table I shows the result of the investigation obtained with 29 filters of the Pasteur-Chamberland type. The total number of people served by these 29 filters is 316. The average of the results of the examination of the effluents is unduly influenced by filter No. 77. Apparently, the storage reservoir has been contaminated; hence the poor result does not indicate that the filter itself was inefficient. As a matter of fact, a second examination a few weeks later gave results in keeping with the other results obtained with this type. In two of the filters, viz: Nos. 2 and 37, of the Globe Reservoir type, in which the reservoir is directly attached to the middle part containing the candle, the bacterial result is very good, as well as the physical improvement.

In filter No. 14 the care of the filter is reasonably good. The candle is washed once or twice a week and baked once every two weeks, yet the harmless types growing on gelatin are present in larger number in the effluent than in the raw water, although the suspicious species are completely eliminated. The water had been stored in the storage reservoir for some time, hence the increase is undoubtedly the result of multiplication of a few bacteria present at the start. As a rule, the candle will furnish more water in a given time at the beginning than later during service. The reason for this is apparent. The yield will lessen as the porosity of the filter decreases. Exposing the candle to heat, or "baking" it, as it is commonly called, will improve the yield for some time afterwards. Apparently, good bacterial results can be obtained without baking the candle at frequent intervals. The candle in No. 35 has not been baked for the last three years, but merely brushed once a week. Candles No. 41 and 54 have not been baked for the last four years, and there are others which have not been baked for a few years past, yet the bacterial results are highly satisfactory. In filters 2 and 47, the candles are brushed but once a month, and have not been baked for the last ten years, if the information obtained can be relied upon, yet the bacterial efficiency is excellent. It seems to be the general practice to brush the candle once a day or two to three times a week. Apparently the bacterial efficiency is not influenced by the frequency of cleaning, which seems to verify our assumption that the bacteria propagate in the water after it has passed the filter and that the filter as such is doing what it is expected to do. We have not considered the influence of frequency of cleaning on yield, but we have no doubt that there is some.

In the Red Cross type of filter the water is passed through unglazed porcelain. The filtered water is cooled in a small tightly closed reservoir connected with the filter. The filter is not sold outright, but is rented with an inspection service to visit each filter systematically once every month. Table II will show the results obtained with this filter. The number of filters of this type examined was 25, serving 125 people. The record of efficiency of the filter is excellent (table II) demonstrating that an excellent water can be obtained under Chicago conditions from household filters if they are properly constructed and supervised by experts.

The filters of the Chicago Water Purifying Company are likewise rented, with inspection by the concern monthly, but the bacterial results obtained in no way measure up to the results obtained with the Pasteur or Red Cross filters. As a matter of fact, in four out of the seven filter effluents examined, the number of bacteria growing on gelatin was very much higher than in the raw water, and the number of bacteria developed at blood temperature was high in all but two cases. In all but two cases the turbidity was eliminated, however. We did not examine the construction of this filter. The filtered water is passed through a pipe into a coil in the ice chamber of the kitchen refrigerator, to insure a cool supply at all times. This can be drawn either from a faucet underneath the filter or from a faucet on the icebox. We have not examined the efficiency of the filters from the construction standpoint, so we have, therefore, limited our discussion to such details as were self-evident or gathered from advertising literature. We cannot say, therefore, whether the poor results obtained with this filter are due to the quality of the filtering material or to multiplication of bacteria after filtration. We do know, however, that the results obtained and tabulated in table III are unsatisfactory.

We have also examined five filters of the Everson Filter Company of Chicago. According to their literature, the water passes through artificial stone. In some types of this filter, the water is passed in addition through a metal casing filled with charcoal.

Our data indicate that small amounts of turbidity are removed satisfactorily, but that the bacterial efficiency cannot always be depended upon.

Of the other individual filters (table V), the data collected is not sufficient to warrant a final statement on reliability. However, in interpreting the results contained in table V, we would impress on the reader that he should not place too much confidence in one single result that is favorable, and that he should look with suspicion on any filter not eliminating turbidity and practically all bacteria.

The filters of the Cleveland Stamping and Tool Company and the "Success" type contain natural stone as the filtering material, through which the water filters by gravity into a lower chamber serving as a storage basin. Such filters afford opportunity for the multiplication of bacteria, and do not completely remove the turbidity. This holds true also of the "Superlative Germ Proof" filters, a pressure type of filter, in which the filtering medium consists of one or several discs of filter paper. The filters made by the Bowden Single Valve Filter Company, the International Filter Company (Style C), and the Loomis-Manning Company are large pressure filters, usually supplying several apartments or an entire building. In filters of this type the water is first coagulated with alum and subsequently filtered under pressure through sand or similar material. Among the results in table VI there are few in which the bacteria as well as the turbidity are as completely eliminated as was the case with the smaller Red Cross type.

In fairness both to the user and manufacturer, the types of filters which have shown a perfect or nearly perfect removal of bacteria and turbidity should, however, be tested more thoroughly from a bacterial standpoint than we have been able to do in the time available for the preparation of this paper.

TABLE I

Results Obtained with Pasteur Chamberland Devices

SERIAL NO.	NO. PERSONS SERVED	INFLUENT				EFFLUENT			
		Turbidity	Presump. test, B. Coli in 10 cc.	No. bacteria per cubic centimeter		Turbidity	Presump. test, B. Coli in 10 cc.	No. bacteria per cubic centimeter	
				L. L. Agar, 48 hrs., 37°C.	Gelatin, 72 hrs., 20°C.			Agar, 48 hrs., 37°C.	Gelatin, 72 hrs., 20°C.
4	7	30	0	1	20	5	0	0	0
11	5	30	0	4	140	0	0	1	2
14	14	30	1	3	55	5	0	0	140
15	8	30	0	10	100	0	0	0	2
28	6	15	0	2	35	0	0	0	0
34	6	30	3	5	110	5	0	0	20
35	5	20	1	2	80	0	0	0	30
37	5	25	2	5	....	0	0	0	....
38	7	20	2	2	....	0	0	0	....
39	7	20	0	1	....	0	0	0	....
41	12	20	1	4	....	0	0	0	....
44	10	15	0	2	....	0	0	0	....
45	3	50	1	5	80	0	0	0	3
47	5	80	0	14	230	0	0	0	1
54	5	15	0	1	25	0		0	0
55	3	15	3	1	30	0	0	0	0
59	6	15	0	4	33	0	0	0	0
61	8	25	1	0	30	0	0	1	0
65	6	20	0	0	10	0	0	0	0
66	4	25	1	0	9	0	0	1	0
75	2	70	0	14 (3 acid)	55	0	0	4	0
76	3	70	1	Subtilis growth	160	0	0	0	0
77	150	50	0	12	140	0	0	560	4800
78	6	50	0	10 (1 acid)	30	0	0	0	2
79	3	50	0	12	20	0	0	0	0
2	3	40	0	3	160	0	0	0	0
12	6	40	1	7	38	0	0	0	0
7	3	30	0	2	10	5	0	10	1
16a	8	0	0	0	30	0	0	0	0

TABLE II

Results obtained with Red Cross filters

SERIAL NO.	NO. PERSONS SERVED	INFLUENT				EFFLUENT			
		Turbidity	Presump. test, B. Coli in 10 cc.	No. bacteria per cubic centimeter		Turbidity	Presump. test, B. Coli in 10 cc.	No. bacteria per cubic centimeter	
				L. L. Agar, 48 hrs., 37°C.	Gelatin, 72 hrs., 20°C.			L. L. Agar, 48 hrs., 20°C.	Gelatin, 72 hrs., 20°C.
13	7	40	0	4	32	5	0	0	0
17	5	20	0	1	15	0	0	0	0
18	4	25	1	1	50	0	0	0	0
19	5	20	0	3	72	0	0	0	0
20	2	30	0	2	18	0	0	0	0
21	6	20	0	0	90	0	0	1	1
29	4	25	1	7 (1 acid)	120	0	0	0	0
30	4	25	0	7 (1 acid)	120	0	0	0	0
42	4	10	1	1	....	0	0	0	....
46	6	50	0	8	105	0	0	0	0
49	6	50	0	5	70	0	0	0	2
50	7	30	2	10	70	0	0	0	0
51	5	15	2	1	10	0	0	0	0
52	4	10	0	0	5	0	0	0	0
57	5	15	0	1	6	0	0	0	0
58	6	15	0	3	20	0	0	0	0
70	4	80	3	25 (1 acid)	160	0	0	0	0
71	4	80	1	20 (4 acid)	120	0	0	0	0
72	2	30	0	3	14	0	0	0	0
73	3	30	0	6	14	0	0	0	0
74	7	30	1	6 (2 acid)	18	0	0	0	0
60	6	20	1	0	15	0	0	0	0
62	5	30	0	2	45	0	0	0	0
63	10	20	0	0	18	0	0	0	0
67	4	25	1	1	22	0	0	0	0

TABLE III

Results obtained with filters of the Chicago Water Purifying Company

SERIAL NO.	NO. PERSONS SERVED	INFLUENT				EFFLUENT			
		Turbidity	Presump. test, B. Coli in 10 cc.	No. bacteria per cubic centimeter		Turbidity	Presump. test, B. Coli in 10 cc.	No. bacteria per cubic centimeter	
				L. L. Agar, 48 hrs., 37°C.	Gelatin, 72 hrs., 20°C.			L. L. Agar, 48 hrs., 37°C.	Gelatin, 72 hrs. 20°C.
22	6	20	0	0	90	0	0	500	13,000
23	5	20	0	0	90	0	0	0	12
24	6	20	0	0	90	0	0	3	4
25	5	25	0	1	48	10	0	2	25
26	6	20	0	0	42	10	0	4	4,000
27	6	15	0	2	35	0	0	4	850
31	4	25	0	3 (1 acid)	75	0	0	0	120

TABLE IV

Results obtained with filters of the Everson Filter Company

SERIAL NO.	NO. PERSONS SERVED	INFLUENT				EFFLUENT			
		Turbidity	Presump. test, B. Coli in 10 cc.	No. bacteria per cubic centimeter		Turbidity	Presump. test, B. Coli in 10 cc.	No. bacteria per cubic centimeter	
				L. L. Agar, 48 hrs., 37°C.	Gelatin, 72 hrs., 20°C.			L. L. Agar, 48 hrs., 37°C.	Gelatin, 72 hrs. 20°C.
33	5	20	0	2	100	0	0	0	5
43	3	10	1	2	....	0	0	96	....
64	6	30	2	0	10	0	0	0	0
68	6	20	1	0	25	0	0	1	0
80	350	50	1	15 (1 acid)	250	0	0	9	10

TABLE V

Results obtained with filters of various other types

SERIAL NO.	NO. PERSONS SERVED	TYPE OF FILTER	INFLUENT				EFFLUENT			
			Turbidity	Presump. test, B. Coli in 10 cc.	No. bacteria per cubic centimeter		Turbidity	Presump. test, B. Coli in 10 cc.	No. bacteria per cubic centimeter	
					L. L. Agar, 48 hrs., 37°C.	Gelatin, 72 hrs., 20°C.			L. L. Agar, 48 hrs., 37°C.	Gelatin, 72 hrs., 20°C.
36	6	Allen Filter Company (a)	20	1	1	....	0	0	0	....
48	4	Allen Filter Company (a)	30	0	4	90	0	0	40	Liquefaction
81	8	Allen Filter Company (a)	50	1	6	30	0	0	4	0
1	2	"The Leader"	30	0	8 (1 acid)	60	20	0	1	11
32	4	"The Leader"	25	0	3 (1 acid)	75	0	0	0	220
6	2	"Eclipse" (g)	30	0	3	28	10	0	1	2
56	4	"Eclipse" (g)	15	0	3	10	0	0	0	0
9	6	Cleveland S.&T. Company (b)	20	0	1	15	10	0	2	7500
8	7	Cleveland S.&T. Company (b)	20	0	4	10	5	0	0	10
5	4	The Success Filter (h)	20	0	2	8	10	0	25,000	Liquefaction
10	300	Lynn. Style C-1 (c)	30	1	4	124	5	0	0	0
53	5	Knoble Filter Company (i)	15	3	2	25	0	0	0	0
84	5	Loomis (d)	15	3	1	30	0	0	2	3
83	6	Bowden (j)	15	0	1	25	0	0	0	5
82	5	"Superlative" (e)	40	1	7	440	30	1	8	40
40	30	"Superlative" (e)	20	0	2	....	5	0	350	....
16	8	Style C Intern. (k)	10	0	3 (1 acid)	40	0	0	0	30
69	12	Crystal F. F. Company (f)	20	0	0	12	10	0	0	0
3	3	The Dayton (l)	40	0	5	140	5	0	1	0

(a) Allen Germ Proof Filter Co.
(b) Cleveland Stamping & Tool Co.
(c) Lynn Filter Mfg. Co., Style C-1.
(d) Loomis Manning Filter Co.
(e) "Superlative Germ Proof," International Filter Co.
(f) The Crystal Fountain Filter Co., Dayton, O.
(g) The "Eclipse," Hygeia Filter Co., Detroit, Mich.
(h) The Success Filter Mfg. Co., Red Wing, Minn.
(i) Knoble Filter Co., Style B.
(j) Bowden Single Valve Filter.
(k) International Filter Co., Style C.
(l) Crystal Fountain Filter Co., Dayton, O.

DISCUSSION

Mr. J. M. Diven: This paper calls to mind a story: The lady of the house was getting her morning glass of water and asked the maid what was the trouble with the water that gave it such a peculiar taste. The maid replied, "The water is all right, mom, there are none of those live bugs or bacteria in it, I killed them." The mistress asked, "What did you put in to kill them?" "I put nothing in it?" "What did you do?" "Sure, I ran the water through the meat chopper twice before I put it in the cooler."

Mr. F. L. Rector: The speaker has recently tested several types of household filters, five in all. In no case did they deliver a uniform effluent, and the average results of a test continuing for several weeks showed the filtered water to be higher in bacteria than the raw water. Counts as high as 20,000 per cubic centimeter were found in filtered water while raw water on a corresponding date showed only 14 per cubic centimeter.

These filters represented both the so-called "self-cleaning" type, and those using unglazed porcelain in some form.

The speaker does not consider any type of household filter effective, as the best they can do is to remove suspended matter from the raw water. Odors, tastes and bacteria will penetrate any of them. They give a false sense of security to the user by improving the appearance of the water, while actually adding to, rather than taking away the bacteria which may be present.

Mr. J. M. Diven: If the city is not going to filter its entire water supply, the speaker believes that it is its duty to furnish pure water. If they are going to rely on household filters to furnish this pure water, it is up to the city to take care of the filters and see that they are properly sterilized and kept in condition. We do all that at our filter plant; we see that the filters are clean, that the clear water reservoirs are clean. Not one in ten thousand domestic consumers will see that their filters are in a sterilized condition. They are satisfied if the water comes through clear. If the turbidity is removed and the small fish taken out, and the water is cool and palatable, the filter is forgotten. It would probably be vastly cheaper for the city to filter the entire supply than to attempt to send inspectors to take care of several thousand household filters.

Mr. Sheppard T. Powell: The speaker's experience with household filters, and he has tested many different types, is that nine times out of ten the water is worse after it leaves the filter than when it enters.

Mr. Wilson F. Monfort: After a sufficiently long period of time has elapsed without cleaning such filters, there is no doubt whatever that the organisms do go through as mentioned in the paper; but probably the idea is that the results are better if the filters are taken care of properly. The speaker's experience some years ago was that the household filter is often left unattended, and one can get a nice slimy growth in the outlet. It is necessary that it be sterilized at least once or better twice a week, which seems to obviate the difficulty. The speaker has tried that in his own case and finds that it works out very nicely.

Mr. Sheppard T. Powell: Taking the general run of household filters that are left to the servants, very little attention is given them and you will generally find the effluent bad. This is because of the lack of care given to the filter rather than to any defect in its mechanical construction.